VIVEKANANDA COLLEGE
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NAAC ACCREDITED 'A' GRADE

Topic: Magnetic Properties

Course Title: Applied Physics

Paper: CC-3

Unit:

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Magnetism in Solids

Magnetism was observed as early as 800 BC in a naturally occurring material called load stone which was used for navigation purposes. In the modern concept, all materials, viz., metal, Semiconductors and insulators, are said to exhibit magnetism, though of different nature.

Magnetic Terminology :-

When a solid is placed in a magnetic field, it gets magnetised. The magnetic moment per unit Volume developed inside a solid is called magnetization and is denoted by M. Another important parameter called the magnetic Susceptibility, χ, which is a measure of the quality of the magnetic material and is defined as the magnetization produced per unit applied magnetic field,

$$\chi = M/H. \quad \text{—(1)}$$

where, H = strength of the applied magnetic field, also referred to as the magnetic field intensity.

The magnetic induction or magnetic flux density B produced inside the medium as a consequence of the applied magnetic field H is given by

$$B = \mu_0 (H+M) \quad \text{—(2)}$$

where μ_0 is the permeability of the free Space or Vacuum and is equal to $4\pi \times 10^{-7}$ Henry per metre. (Hm^{-1}).

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Using eqn (1) and eqn (2),

$$B = \mu_0(1+\chi)H \quad \text{——(3)}$$

or $B = \mu H$ ——(4)

where μ is called absolute permeability of the medium.

$$\mu = \mu_0 \mu_r \quad \text{——(5)}$$

where μ_r is called the relative permeability of the medium.

So from eqn (4)

$$B = \mu_0 \mu_r H \quad \text{——(6)}$$

From eqn (3) and eqn (6)

$$\mu_r = 1 + \chi \quad \text{——(7)}$$

For free space, i.e, in the absence of any material, $M = 0$, $\chi = 0$, $\mu = \mu_0$ and $\mu_r = 1$, and from the above relations, we obtain

$$B = \mu_0 H.$$

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Types of Magnetism:-

The magnetism in solid has been classified into the following five categories:

(i) Diamagnetism.
(ii) Paramagnetism.
(iii) Ferromagnetism.
(iv) Antiferromagnetism.
(v) Ferrimagnetism.

The magnetism in solids arises due to orbital and spin motions of electrons as well as spins of the nuclei. The major contribution comes from the spin of unpaired Valence electrons which produces permanent electronic magnetic moments. A number of such magnetic moments may align themselves in different directions to generate a net non-zero magnetic moment. Thus the nature of magnetization produced depends on the number of unpaired Valence $e^{\ominus}$.

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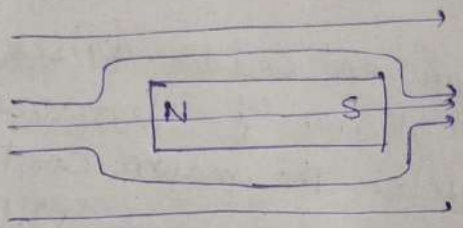
Diamagnetic Metarials:-

i) Diamagnetic substance are those substance which are feebly repelled by a magnet.

ii) when placed in a magnetic field, it acquire feeble magnetism opposite to the direction of magnetic field.

iii) when placed in magnetic field the lines of force tend to avoid the substance.



iv) when diamagnetic solution is poured into a utube and one arm is placed between the poles of strong magnet the level of solution in that arm is lowered.

v) Diamagnetic metarial does not have a single unpair electron.

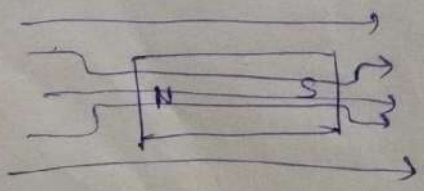
vi) NaCL, TiO_2, V_2O_5.

Paramagnetic Metarials:-

i) Paramagnetic substance are those substance which are feebly atracted by a magnet.

(ii) when placed in a magnetic field, it acquire feeble magnetism to the direction of magnetic field.

iii) when placed in magnetic field the line of force pass through the substance.



iv) Paramagnetic metarial has atleast one unpair electron.

v) Cu^{+2}, fe^{+3}, TiO.

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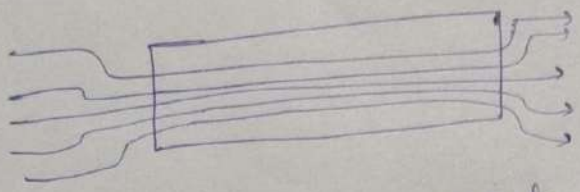
Ferromagnetic Metarial

i) strongly attracted by magnet.

ii) when place in a magnetic field, it accquire strong magnitism in the direction.

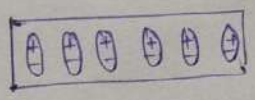
iii) when placed in magnetic field the lines of force croud into the specimens.



iv) Itself behave like a magnet after removal of external magnetic field.

v) ~~Net m~~ Eg → Fe, Ni, CrO_2

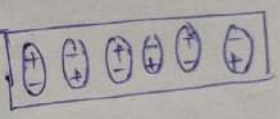
vi) Net dipole ~~mom~~ moment is maximum.



Antiferromagnetic Metarial

i) strongly repelled by magnet.

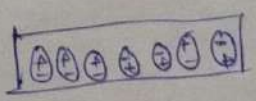
ii) Net dipole moment is zero.



iii) Fe_2O_3, MnO, MnO_2, ~~M~~ Mn_2O.

Ferrimagnetic Metarial.

i) Net dipole moment is non zero but less than Ferromagnetic metarial.



ii) Fe_3O_4.

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